HEADER FOR SURFACE MOUNT BETWEEN PARALLEL CIRCUIT BOARDS

BACKGROUND OF THE INVENTION

The present invention relates to interconnect devices used in electronic assemblies, and more particularly, to devices that require a surface mount to surface mount attachment of a conductive circuit on a first printed circuit board to a conductive circuit on a second parallel printed circuit board.

In the electronics industry there is frequently a need to connect circuitry formed on a first printed circuit board with circuitry formed on a second printed circuit board which is closely adjacent to, and parallel, to the first circuit board. In the past, ribbon cables, edge card connecters and other flexible wire interconnect assemblies have been developed for this purpose. However, they are relatively expensive, particularly where disconnectable couplings are not required. This is often the case where a so-called "mother board" in a personal computer is connected to a dedicated graphics processing board, for example.

Various approaches have also been developed for interconnecting adjacent parallel circuit boards utilizing conductive pins. These conductive pins are typically rigid and are attached by re-flowed solder paste commonly known in the industry as "pin and paste" or butt-solder joint" attachment. However, utilizing this type of interconnect to mechanically and electrically connect parallel circuit boards has been problematic. Pin and paste or butt-solder joint attachments use minimal solder paste which results in inferior joints. The circuit boards are not co-planar and this varies the amount of solder between the pins and the opposing conductive pads, resulting in excessive elongation of joints and leaving thin sections of solder attachment which are weak. Differences in thermal expansion between the two circuit boards can cause the inferior solder joints to exhibit fractures that can result in high resistance or open circuits.

Besides providing electrical interconnections between adjacent circuit boards, it is desirable to apply the same interconnection scheme to provide the mechanical support between the printed circuit boards, thereby reducing the overall parts costs. It would therefore be desirable to provide an improved low-cost reliable device for providing electrical and mechanical connections between adjacent printed circuit boards. It would further be desirable that this device be readily adapted for interconnecting printed circuit boards that are designed for so-called "surface mount technology" (SMT) mounting of electronic components thereon. Current SMT techniques utilize so called "dog bone" conductive traces or pads that provide large rounded areas for the solder balls that are remote from the vertical connectors. This offset approach is wasteful in terms of requiring excess amounts of circuit board real estate.

SUMMARY OF THE INVENTION

In accordance with the present invention a header comprises a substrate made of an insulative material and having a plurality of through holes formed therein extending between upper and lower sides of the substrate. Plating is applied to the through holes to form conductive cylinders with upper and lower ends. A plurality of solder balls or other pre-formed heat re-flowable bonding members are attached directly to corresponding upper and lower ends of the conductive cylinders.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a top plan view of a solder ball header forming a preferred embodiment of the present invention.

Fig. 2 is a side elevation view of the solder ball header of Fig. 1 taken from the top of Fig. 1.

Fig. 3 is an enlarged vertical section view of the solder ball header taken along line 3-3 of Fig. 2. This figure is not drawn to scale.

Fig. 4 is a vertical sectional view of the solder ball header of Figs. 1-3 interconnecting upper and lower printed circuit boards. This figure is not drawn to scale.

Fig. 5 is a top plan view of an alternate embodiment of the solder ball header of the present invention.

Fig. 6 is a side elevation view of the alternate embodiment of Fig. 5.

Fig. 7 is a top plan view of another embodiment of the header of the present invention.

Fig. 8 is a sectional view taken along line 8 - 8 of Fig. 7 illustrating the mounting of the header of Fig. 7 on a circuit board via locator pins. This figure is not drawn to scale.

Fig. 9 is a top plan view of another alternate embodiment including an outrigger support.

Fig. 10 is a sectional view of the alternate embodiment of Fig. 9 taken along line 10-10 of Fig. 9.

Fig. 11 is a top plan view of another alternate embodiment including an H-shaped substrate.

Fig. 12 is an end elevation view of the alternate embodiment of Fig. 11 taken from the right hand side of Fig. 11.

Fig. 13 is a top plan view of another alternate embodiment including a stright substrate segment with guide pins.

Fig. 14 is an end elevation view of the alternate embodiment of Fig. 13 taken from the right hand side of Fig. 13.

Fig. 15 is a top plan view of another alternate embodiment including a straight substrate segment and flat solder pads.

Fig. 16 is an end elevation view of the alternate embodiment of Fig. 15 taken from the right hand side of Fig. 15.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to Figs. 1 and 2, a generally C-shaped header 10 includes a substrate 12 made of a suitable dielectric (insulating) material such as FR-4 glass filled epoxy. A plurality of holes are drilled through or otherwise formed in the substrate 12 and are plated to provide conductive cylinders such as 14. Each conductive cylinder 14 is formed with an axially extending hole 15a in the center thereof which is flared at either end. The axially extending hole 15a (Fig. 3) is plated solid, filled with solder or epoxy, or filled by inserting a pin. A generic plug 15b is illustrated in Fig. 3 filling the hole 15a. The plug 15b may be formed by any of the foregoing techniques.

The holes formed through the substrate 12 could be countersunk at either end in order to ensure that cylindrical or disc-shaped end portions 14a and 14b are formed on either end of the conductive cylinder 14. Generally round solder balls 16 are automatically deposited onto the end portions 14a of each of the conductive cylinders 14 and are heated a sufficient amount so they will bond to the upper ends of their corresponding conductive cylinders 14. The header 10 is then inverted, and solder balls 18 are deposited on the end portions 14b of the conductive cylinders 14, and heated a sufficient amount to bond thereto. Solder balls 16 and 18 may be made of, for example, a 63-37 weight percent alloy of tin and lead.

The solder ball header 10 may be utilized to provide a permanent mechanical and electrical connection between upper and lower planar printed circuit boards 20 and 22 (Fig. 4). The circuit boards 20 and 22 of this assembly are formed of any suitable dielectric (insulating) substrate material,

such as FR-4 glass filled epoxy. Conductive traces or pads such as 24 and 26 are formed on the circuit boards 20 and 22, respectively, in conventional fashion. Preferably these conductive traces or pads 24 and 26 are suitable for SMT mounting of electronic components. Conductive traces and pads are collectively referred to herein as conductive elements. In an assembly line, the circuit board 20 is conveyed past a robotic machine which places one or more solder ball headers such as 10 onto the upper surface of the printed circuit board 20 so that the solder balls 18 register with corresponding conductive pads 24. The solder ball header 10 is comprised of a main leg 12a which extends in a longitudinal direction, and two smaller legs 12b and 12c which extend in the lateral direction. This C-shaped configuration of the solder ball header 10 prevents it from tipping over as the circuit board 20 is conveyed along the assembly line.

Next, the upper circuit board 22 is automatically placed on top of the solder ball headers, such as 10, so that its conductive pads 26 register with corresponding solder balls 16 on the upper side of solder ball header 10. Thereafter, the entire assembly is sufficiently heated to re-flow the solder balls 16 and 18. The solder balls 16 and 18 re-melt, and wrap around the vertical side edges of the conductive pads or traces 24 and 26 and around the vertical side walls of the end portions 14a and 14b of the plated-through conductive cylinders 14. This provides increased strength to the entire assembly of the circuit boards 20 and 22 and the solder ball headers 10 once the solder balls cool and harden. Preferably, the re-flow process is controlled so that the solder balls 16 and 18 stay substantially rounded.

The height or thickness of the solder ball header 10 is chosen to achieve the desired spacing D between the opposing faces of the circuit boards 20 and 22. These circuit boards are preferably mechanically and electrically connected so that the planes of their opposing faces are substantially parallel. The additional solder provided by the solder balls 16 and 18 accommodates lack of co-planarity in the circuit boards 20 and 22 and any relative differences in their thermal expansion. If the conductive cylinders 14 are solid, i.e. incorporate the plug 15b, there will be no chance that solder from one of the solder balls could wick or otherwise flow into a hole in the cylinder due to dissimilar heat profiles, thereby leaving less solder to form a proper joint.

Fig. 5 illustrates an alternate embodiment 30 of the present invention configured for handling by the pneumatic head of an automatic pick and place machine. It includes a rectangular frame 32 made of suitable dielectric (insulative) material defining a large rectangular opening 34 spanned by a central cross-beam 36. Cross-beam 36 has a central circular region 36a which is sucked up to the pneumatic head of the automatic pick and place machine. The frame 32 has plated-through holes (not visible) providing conductive cylinders similar to conductive cylinders 14 of the solder ball header 10. As best seen in Fig. 6, solder balls 38 and 40 are bonded to the upper and lower ends of these tubular conductors. The solder balls 38 and 40 serve the same function as the solder balls 16 and 18 of the solder ball header 10 when the second embodiment 30 is used to interconnect lower printed circuit boards.

Referring to Figs. 7 and 8, yet another embodiment 50 of the header of the present invention includes a longitudinally extending rectangular substrate 52. Longitudinally spaced, laterally offset locator pins 54 and 56 extend from the lower side of the substrate 52. Longitudinally spaced, laterally offset locator pins 58 and 60 extend from the upper side of the substrate 52. The locator pins 54 and 56 are received in locator holes such as 62 formed in a lower circuit board 64. The locator pins 58 and 60 are received in locator holes in an upper circuit board, not illustrated. The substrate 52 has conductive cylinders 66 (Fig. 8) which have plugs 68. Solder balls such as 70 and 72 are attached to the upper and lower ends of each of the conductive cylinders 66 which form rings. The locator pins 54, 56, 58 and 60 ensure precise registration of the header 50 with the upper and lower circuit boards and prevent the header 52 from tipping over during solder re-flow. The locator pins also eliminate any need for the substrate to have a laterally extending leg like the C-shaped header 10 of Fig. 1. The solder ball 72 illustrated in Fig. 8 bonds the lower end or ring of the conductive cylinder 66 to a conductive trace 74 formed on the upper side of the lower circuit board 64. The trace 74 terminates in a circular pad 74a to which solder ball 72 is bonded.

In the embodiments described above, solder balls have been utilized to form the electrical and mechanical interconnections between the upper and lower circuit boards. However, it will be

understood by those skilled in the art that the solder balls could be replaced with a wide variety of pre-formed heat re-flowable bonding members that can be heated to cause them to re-flow and thereafter, when allowed to cool and re-solidify, will provide an electro-mechanical connection between the two circuit boards. For example, shaped solder deposits formed from solder paste could be utilized. See U.S. Patent No. 6,158,650 of Holzmann granted December 12, 2000 and assigned to Mask Technology, Inc., the entire disclosure of which is hereby incorporated by reference. These shaped solder deposits could have a washer configuration, a rectangular configuration, or any other suitable configuration. Besides Tin/Lead alloys, the pre-formed heat re-flowable bonding members could be made of Tin/Bismuth alloy, conductive epoxy, brazing compound, welding compound and the like.

Referring to Figs. 9 and 10, an alternate embodiment 80 includes a straight segment of substrate 82 having a rectangular cross-section and formed intermediate its length with a general semi-circular outrigger support 84 which serves to stabilize the device and prevent it from tipping over on top of circuit board. The straight substrate segment 82 and the outrigger support 84 are each formed with plated through-holes (not visible) on top of which are deposited solder balls 86. The outrigger support 84 has solder balls 86 on only one side thereof.

Referring to Figs. 11 and 12, an alternate embodiment 90 includes a generally H-shaped substrate 92 having parallel, elongated straight substrate segments 92a and 92b connected by an intermediate segment 92c. The intermediate segment 92c has a central circular area 92d to facilitate pick up by a suction head of an automatic pick and place machine. The straight segments 92a and 92b are each formed with plated through-holes (not visible) and solder balls 94 are attached to opposite ends of these plated through-holes.

Referring to Figs. 13 and 14, another embodiment 100 includes a straight substrate segment 102 formed with plated through-holes (not visible). Solder balls 104 are attached to the opposite ends of each of the plated through-holes. Pins 106 extend from each end of the straight substrate

segment 102 at each end thereof on one side of the segment 102 for registration with mounting holes in a printed circuit board.

Referring to Figs. 15 and 16, another embodiment 110 includes a single straight substrate segment 112 with plated through-holes (not visible) having rectangular solder flat pads 114 attached to the opposite ends of the plated through-holes.

While the present invention has been described in terms of several embodiments, it should be apparent to those skilled in the art that the subject invention can be modified in both arrangement and detail. The pre-formed heat re-flowable bonding members could be arranged in any pattern on the substrate, including irregular patterns. Also, the references to upper and lower are merely for the sake of clarity in describing the relationship of the structures, which can be placed in any orientation. Therefore, the protection afforded the invention should only be limited in accordance with the scope of the following claims.

WHAT IS CLAIMED IS: